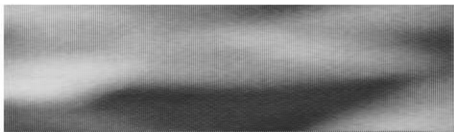
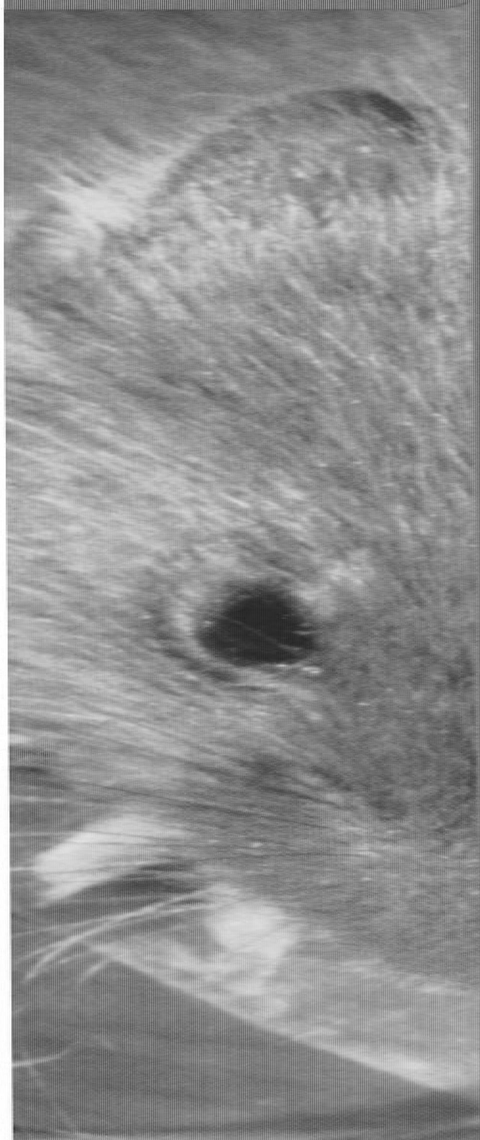
High School Biology & the Physics First Movement
Author(s): Rodger W. Bybee and April L. Gardner
Reviewed work(s):
Source: *The American Biology Teacher*, Vol. 68, No. 3 (Mar., 2006), pp. 134+136+138
Published by: University of California Press on behalf of the National Association of Biology Teachers
Stable URL: http://www.jstor.org/stable/4451950
Accessed: 04/01/2012 12:20



GUEST EDITORIAL



High Sch

Among myriad issu fronting biology teachers a cates for "Physics First." teach physics first, usually grade, followed by chemis then biology. This places first and biology last. Eve placement makes con sense, the title lacks a con vision. Let's not be distra the title, at least for now. W with some information ab Physics First movement.

In 1998, Leon Leder Nobel Laureate in Physics, that the biology-chemistry sequence of high school courses was outdated. Mod ence had advanced to a po required a change in the tra sequence. Lederman p that a curricular sequen began with physics and pr to chemistry and biology modated the dramatic a that have occurred in scie ing the past century. The a based on the Human Project and molecular serve as clear and compell logical examples.

Few would question t that understanding moder gy requires a basic know physics and chemistry. Fo ple, fundamental princi physics were required to de the structure of DNA, ar concepts of chemistry expl DNA functions as the repo heritable information a director of cellular meta Without a conceptual und ing of physics or chemis dents are constrained by a tive approach to biology a ed to the memorization such as "double helix" or RNA to protein." Based o

First, shouldn't the physics topics and emphasis change if one knew that chemistry and biology would follow? Similarly, shouldn't the topics and/or sequence of topics in chemistry change if one knew that students had studied fundamental physics concepts? And, of greatest relevance to this audience, how would one structure a biology course for students who are prepared to apply, for example, laws of motion and chemical bonding? Second, how does one accommodate the fact that many state assessments are administered at tenth grade and include biology? Finally, the question of the place of other science disciplines, in particular Earth science (an issue in the traditional biology-chemistry-physics sequence) remains in the reversed sequence approach. We also note that there is not a major curriculum designed primarily with a Physics First orientation.

Figure 1.
Physics-Chemistry-Biology (Earth Science) in Sequence

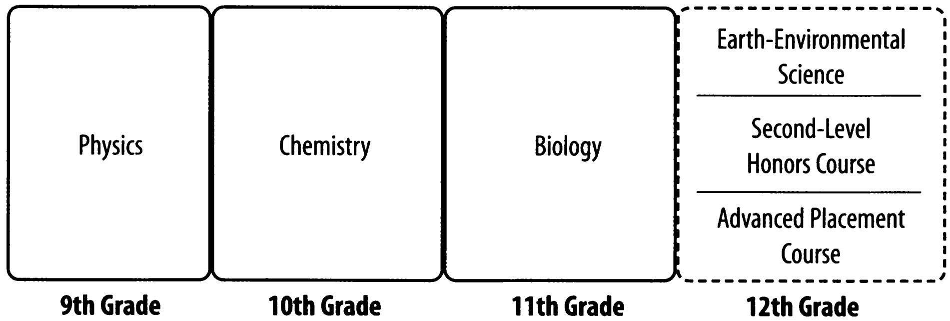
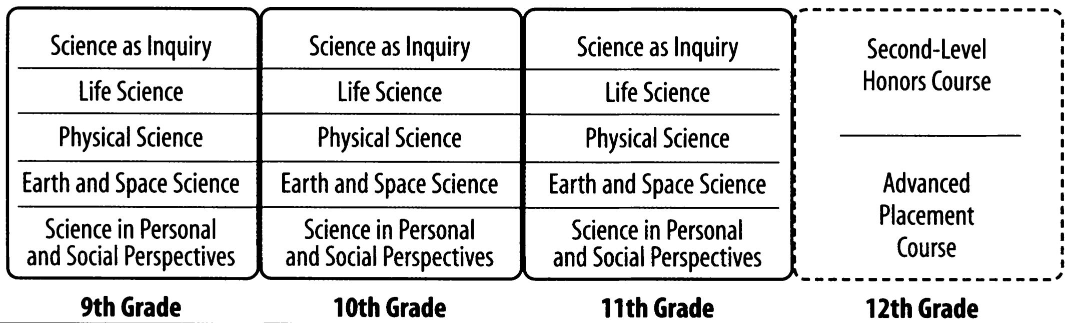


Figure 2.
Physical, Life, and Earth Science Each Year



Re-ordering of the typical high school curriculum, with modifications in the content of the physics and biology courses to accommodate developmental differences in the students, does not address these important issues. Furthermore re-ordering the physics, chemistry, biology, and Earth science courses and continuing to treat them as discrete, unconnected packages misses an intent of the original proposition. Proponents of the Physics First approach explain that the rationale for this course sequence is that the sciences themselves have a natural hierarchy. At the most fundamental level, physics has precise descriptions of natural phenomena such as forces and motions. The laws of chemistry are logically supported by physics concepts. Concepts in biology are underpinned by the laws of physics and chemistry. As Leon Lederman asserts, "The P-C-B sequence should coexist with story lines or branches which cause students to revisit, reapply, support or even challenge previous experiences and understanding ... Looking bidirectionally–from physics forward and biology back–curriculum choices are informed by numerous logical and appropriate connections within and between disciplines" (Lederman, 1998). The "simple re-ordering" suggested by Figure 1 is not so simple after all, and demands substantive rethinking of each high school science course and dialogue among teachers of all science disciplines.

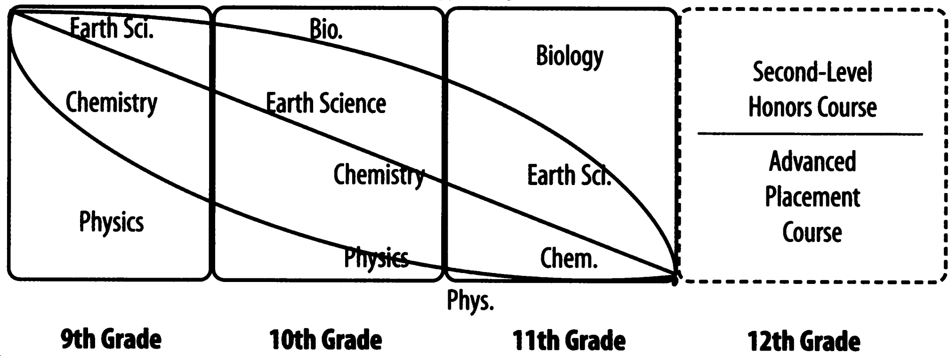
A second non-traditional approach to high school science incorporates physical, life, and Earth science units as the core of a year-long course, each year for a three-year program. Students experience concepts from each science discipline in contexts associated with inquiry and personal and social issues. The connections across the disciplines emerge in the latter contexts. The desired result is a coherent presentation and hopefully, learning of science concepts across traditional disciplinary boundaries. Note that Earth and space science can be included in the yearly sequence. This design is the basis for *BSCS Science: An Inquiry Approach*. The curriculum framework for this program is illustrated in Figure 2. To make this approach consistent with the intent of the Physics First movement, physics could be the first discipline taught (after an introduction to scientific inquiry) each year.

A third curricular design that accommodates the goals of the Physics First movement can be envisioned. In this design students would experience each discipline each year, but with a graduated scheme (Figure 3). More physics would be included in 9th grade and more biology in 11th grade. Chemistry and Earth science have curricular time in each year of the three-year sequence.

This approach allows for topics from each of the sciences that require more sophisticated skills in mathematics to be taught later in the program after those skills have been developed. AAAS' Project 2061 team suggested this approach in its

statement, "Perhaps the ideal schedule would stretch all science subjects out over time, with ideas sequenced in a way that would allow them to be taught when they are needed and learnable, without regard to discipline, but with the disciplines supporting each other" (AAAS, 2001). Nevertheless, the task of designing courses for such a program is not trivial. The traditional science courses have a ready discipline-based framework that, in theory, can be used to help create coherence, but integrated courses do not have this advantage. This disadvantage may turn into an advantage, however, because it makes it very clear to designers of integrated courses that they must deliberately build story lines, themes, and interconnections into the courses to create the desired coherence (Rutherford, 2000).

Figure 3.
Physics, Chemistry, Earth Science, and Biology Integrated Each Year



We note that curricular designs suggested by Figures 2 and 3 address issues such as state assessments at 10th grade and the incorporation of Earth science while honoring the original intent of teaching fundamental concepts of Physics First. Very importantly, these curricular designs also honor an original rationale for Physics First: namely the need to increase coherence and connection within the high school science curriculum.

It is this latter point that causes us to give an affirmative answer to one of our original questions: Should biology teachers pay attention to the Physics First movement? Given the recognition that the lack of coherence and rigor in science curriculum is a likely cause of the poor standing of U.S. students in international science tests (Schmidt et al., 2001; Valverde, 1998; Getty & Berman, 2005), any movement that requires the community of science teachers to take a thoughtful look at their curriculum, identify areas where coherence and rigor can be strengthened, and plan courses of action to make those changes is worth paying attention to. Biology teachers are a critical component of this dialogue.

In conclusion, the science education community eventually may have evidence that teaching Physics First enhances coherence and rigor in high school science education. It may even have advantages not originally anticipated. For example, students may bring more sophisticated inquiry abilities and conceptual understanding to biology, thus enhancing the rigor, depth, and breadth of study in our discipline. Students may take more Advanced Placement courses and Honors courses because they have the conceptual depth and intellectual wonder required for continued study. They may be open to courses in science and engineering. These are all testable questions that should be studied.

For the time being, we propose that instead of "biology last" we refer to "Capstone Biology." That is, the culminating ideas in a required program. Staying with the metaphor, physics and chemistry would certainly be the cornerstones, the indispensable and fundamental basis for understanding the natural world. And yes, Earth science could be the bridge stone.

For complex and diverse reasons, some of which were identified at the beginning of this essay, Physics First may never have the far reaching impact currently held by the biology-chemistry-physics sequence. But, the movement has engaged discussions about the science curriculum that are well worth consideration by biology teachers.

Rodger W. Bybee
April L. Gardner
BSCS
Colorado Springs, CO 80918

References

American Association for the Advancement of Science (AAAS). (2001). *Atlas of Science Literacy.* Washington, DC: Author.

BSCS. (2004). *Biology and the Physics First Curriculum: A Symposium Celebrating BSCS's 45th Anniversary.* Colorado Springs, CO: Biological Sciences Curriculum Study.

BSCS. (Spring 2004). *The Natural Selection.* Colorado Springs, CO: Biological Sciences Curriculum Study.

Getty, S. & Berman, M. (Winter, 2005). International competitiveness: Where do we stand? *The Natural Selection,* 28-30.

Lederman, L. M. (1998). *ARISE: American Renaissance in Science Education.* (FERMILAB-TM-2051). Batavia, IL: Fermi National Accelerator Laboratory. Retrieved June 15, 2002, from http://fnalpubs.fnal.gov/archieve/1998/tm/TM-2051.pdf.

Neuschatz, M. & McFarling, M. (2003). *Broadening the base: High school physics education at the turn of a new century.* College Park, MD: American Institute of Physics.

Rutherford, F. J. (2000). Coherence in high school science. In BSCS, *Making Sense of Integrated Science,* pp. 21-29. Colorado Springs, CO: BSCS.

Schmidt, W. H., McKnight, C. C., Houang, R. T., Wang, H. D., Wiley, D. E., Cogan, L. S. & Wolfe, R. G. (2001). *Why Schools Matter: A Cross-National Comparison of Curriculum and Learning.* San Francisco, CA: Jossey-Bass.

Valverde, G. A. (April, 1998). TIMSS high school results released. *TIMSS US National Research Center, Report No. 8,* 1-2.